coast near the border experiences a hot, dry wind similar to the foehn, which raises the temperature considerably.

In winter the north differs somewhat from the south. February is the coldest month, with 68° F. average monthly temperature in the south, and 57° F. in the north.

WIND AND RAIN.

During the winter a strong northeast monsoon blows steadily and this, combined with the mountains, causes heavy rainfall in the north, which lasts for several months. Kashoryo on the hillside near the eastern coast is probably the wettest place in the Far East, having an average rainfall of 7,338 mm. (289 in.). The west coast gets less rain because it is protected by the mountains.

During the summer the southwestern monsoon prevails, and except during the occurrence of a typhoon the winds are light. Frequent thunderstorms give abundant rainfall, and a typhoon will bring several hundred mm. of rain on a single day.

Formosa lies in the highway of the great storms known as typhoons. These storms originate in the sea surrounded by the Philippines, the west Carolines, and the Mariana Islands, or else in the China Sea itself.

The earliest typhoons that visit Formosa occur in May and the latest in November, and sometimes from December to April there are none. August is the month when they generally occur, and their frequency may be judged from the fact that in the 17 years from 1897 to 1913 there were 30 remarkably severe typhoons; 15 of these occurred in August.

The storms move generally toward the northwest or west-northwest, and the northern half of the island of Formosa is directly in that district. The force of the wind is terrific, and there is generally a corresponding ocean swell which is felt on the southwest coast.

Fig. 13 (Chart XV) epitomizes the characteristics of the climate of Formosa.

Average monthly temperature in °C.

(1) Northern zone.			(2) Central zone.			(3) Southern zone. (4) Formosa (tropical zone)		
	Nemuro.	Hakodate.		Tokio.	Niigata.		(3) Nagasaki.	(4) Taikoku.
Jan.	−5.1	−3.1	Jan.	3.0	1.5	Jan.	6.0	15.7
Feb.	−5.5	−2.6	Feb.	3.5	1.2	Feb.	4.4	14.0
Mar.	−2.5	0.7	Mar.	6.8	4.5	Mar.	9.2	16.9
Apr.	3.0	6.4	Apr.	12.6	10.4	Apr.	14.4	20.7
May.	6.6	10.4	May.	16.5	15.0	May.	17.9	23.8
June.	9.8	14.2	June.	20.4	19.3	June.	21.6	26.6
July.	14.1	18.5	July.	23.8	23.5	July.	25.5	27.9
Aug.	17.2	21.3	Aug.	25.4	25.5	Aug.	26.6	27.7
Sept.	15.1	17.4	Sept.	21.8	21.3	Sept.	23.4	26.2
Oct.	10.4	11.4	Oct.	15.8	15.1	Oct.	18.8	23.3
Nov.	4.3	5.3	Nov.	10.3	9.4	Nov.	12.8	19.6
Dec.	−1.4	−0.3	Dec.	5.3	4.1	Dec.	7.9	16.7
No. of years of observation..	33	40	No. of years of observation..	37	31	No. of years of observation..	34	18

Average monthly rainfall in mm.

(1) Northern zone.			(2) Central zone.			(3) Southern zone. (4) Formosa (tropical zone).		
	Nemuro.	Hakodate.		Tokio.	Niigata.		(3) Nagasaki.	(4) Taikoku.
Jan.	28.5	55.8	Jan.	57.1	96.3	Jan.	78.9	91.0
Feb.	21.1	57.7	Feb.	58.0	125.2	Feb.	81.7	130.7
Mar.	43.7	64.1	Mar.	109.2	104.6	Mar.	130.1	175.8
Apr.	70.2	69.3	Apr.	131.8	106.0	Apr.	196.6	137.6
May.	97.7	80.1	May.	156.9	82.8	May.	180.1	204.9
June.	90.6	89.9	June.	153.8	132.9	June.	294.9	241.2
July.	85.9	138.0	July.	143.3	156.9	July.	245.3	207.0
Aug.	94.0	129.3	Aug.	145.2	130.9	Aug.	177.5	246.9
Sept.	134.5	168.4	Sept.	210.6	186.6	Sept.	210.9	233.2
Oct.	88.1	114.3	Oct.	180.1	146.3	Oct.	117.6	102.7
Nov.	79.2	95.8	Nov.	100.3	182.5	Nov.	85.4	72.6
Dec.	62.0	79.3	Dec.	54.1	232.6	Dec.	85.4	93.1
Total...	825.7	1,142.0	Total...	1,500.4	1,793.5	Total...	1,884.4	1,940.1

HISTORICAL NOTE ON CHARTS OF THE DISTRIBUTION OF TEMPERATURE, PRESSURE, AND WINDS OVER THE SURFACE OF THE EARTH.

The state of the atmosphere at any given point is completely determined when we have given the values at that point of the six *meteorological elements*—temperature, pressure, wind, humidity, cloud, and precipitation (electrical state has no influence on the phenomena we are considering). The day to day fluctuations of these elements, caused by disturbances in the atmosphere, constitute *weather*, whereas the "normal" values, obtained by averaging a very long series of observations in order to eliminate the chance irregularities, largely characterize the *climate*. The varying climate found at different localities over a wide area is most conveniently represented graphically by means of isometric charts.

For purposes of theoretical and dynamical meteorology, it is essential to have such charts for the entire globe, without, however, going into any minute climatological details. "Normal" values have but little significance or utility for practical meteorology, other than descriptive climatology, as pointed out, *e. g.*, by J. Rouch, *Préparations Météorologiques pour les Voyages Aériens*, Paris, 1920.

Meteorological phenomena are all due to the flood of energy received from the sun; hence the measurement of the amount of *solar radiation*, and the distribution of *insolation* over the surface of the earth and throughout time, become of fundamental importance as subjects of investigation.[1]

The primary meteorological phenomenon to which insolation gives rise—temperature, and its diurnal and annual variations—must be assigned first place in the chain of cause and effect in meteorology; were the sun blotted out of existence, a lifeless uniformity would take possession of the earth; were the distribution of temperature over the earth always the same and the temperature uniform, a calm equilibrium would ensue.[2] The temperature, pressure, and prevailing winds, because of their intimate relations with one another, are best dealt with together; taken in conjunction with the topography, etc., they determine the distribution of the remaining elements, and the climatological characteristics of any region.

[1] *Cf.* C. Dorno, On Observations of Solar and Sky Radiations and Their Importance to Climatology and Biology and also to Geophysics and Astronomy, MONTHLY WEATHER REVIEW, 48, 18–24, 1920; J. B. Kincer, Sunshine in the United States, MONTHLY WEATHER REVIEW, 48, 12–17, 1920; H. H. Kimball, Variations in the total and luminous Solar Radiation with Geographical position in the United States, MONTHLY WEATHER REVIEW, 47, 769–793, 1919; *Annals of the Astrophysical Observatory of the Smithsonian Institution*, vols. 1–3.

[2] Laplace, *Méc. Cél.*, Bk. 1, Art. 37; Bk. 3, chap. vii. Ferrel, *Rept. U. S. Coast Survey*, 1875, p. 402; W. J. Humphreys, *Physics of the Air*, chap. vii.

Meteorological phenomena were undoubtedly among the first to be noticed by primitive man. The general distribution of temperature over the world has been known since antiquity—Eratosthenes, Polybius, and Strabo were acquainted with the cause of this distribution; long before comparable thermometers were known, or a precise idea of the mean temperature had been formulated, Halley, in 1693, laid the foundations of the theory of the heating power of the sun at different latitudes; in the eighteenth century, Mairan and Lambert wrote on the same subject; Mayer's empiric fomula for determining the mean temperature at any latitude, once the constants had been found by observations at a few stations, played an important rôle for many years.

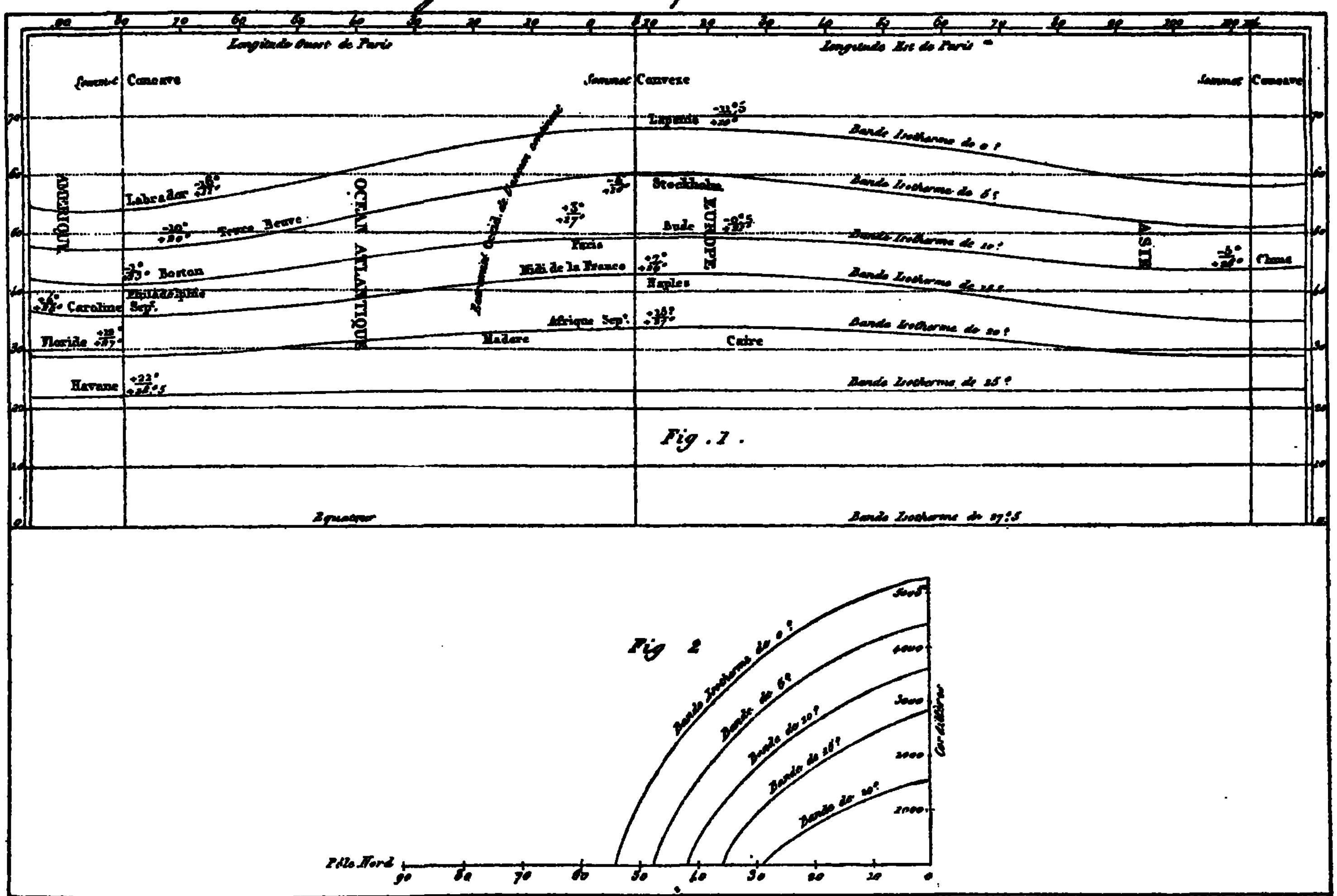
The monsoons of the Indian Ocean have also been known since the earliest times, having been described by Aristotle and the early Arabs; the trades were discovered by Columbus, and their distribution mapped out by the navigators of the sixteenth century. The seventeenth century witnessed the discovery by Torricelli of the barometric pressure of the atmosphere, and its decrease with elevation. Before the exploring expeditions led by Capt. Wilkes and by Sir James Ross (both about 1840), it was pretty generally thought that the barometric pressure at sea level is normally nearly or quite the same at all places—about 30 inches; these expeditions clearly demonstrated that the barometer persistently stood low in the Tropics, higher to either side of the tropical zone, and lower again toward the poles.[3]

Somewhat previous to the opening of the nineteenth century, there was inaugurated a period in the history of meteorology which was marked by the attempt to give logical explanations for the various phenomena. In spite of the great mass of weather lore and observational facts accumulated since the time of the ancients, there had been little or no attempt at a rational theory of meteorological phenomena in general. But meanwhile the sciences of mathematics, physics, hydrodynamics, etc., had been developing; and at the beginning of the nineteenth century, with the chemical nature of the atmosphere at last known, the Gas Laws discovered, and the equations of analytical mechanics available, it became possible to found the science of Dynamical Meteorology. The first theoretical investigation of the atmosphere from this standpoint was given by Laplace (*l. c.*) in the Mécanique Céleste, which contains practically all the then existing knowledge of the subjects treated. His meteorological contributions, however, relate only to an atmosphere in equilibrium, and to atmospheric tides.

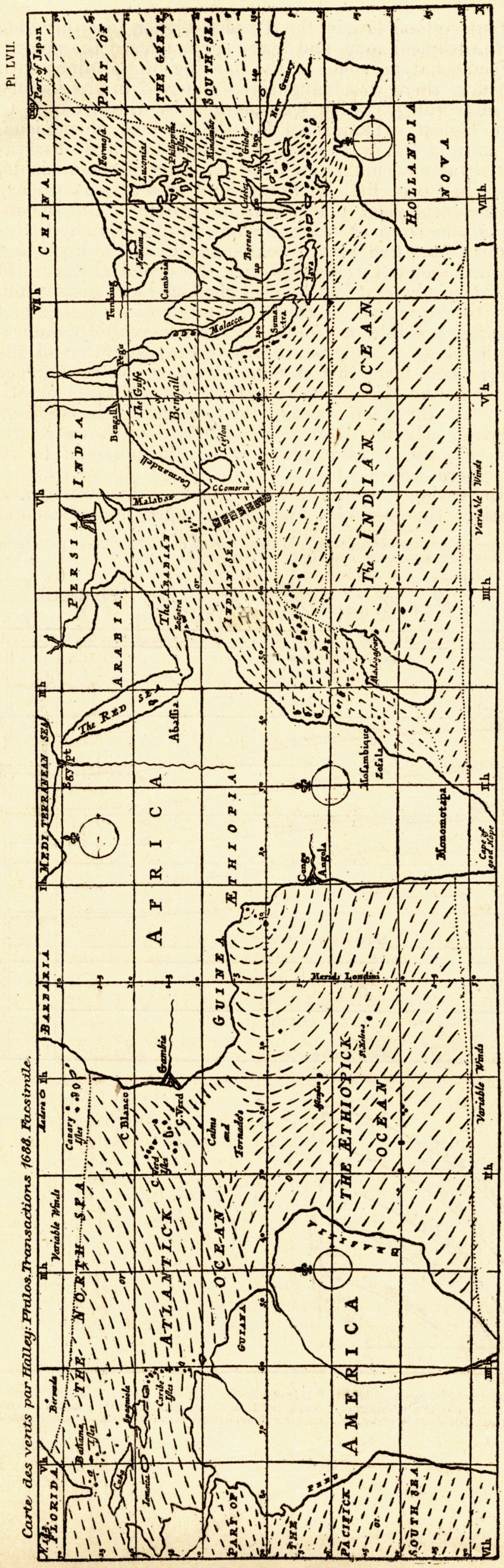
Increasingly accurate and extensive observation also marked this period. The first temperature chart (as

[3] More recent observations have established that in the vicinity of the poles themselves the barometer again stands high.

Carte des lignes Isothermes par Mr. A. de Humboldt Pl. XXIII.



VON HUMBOLDT's Isothermal Chart of the Globe, 1817. First published in the author's reprints of *Des lignes isothermes et de la distribution de la chaleur sur le globe,* Mémoires de physiques et de chimié de la Société d'Arcueil. T. III. p. 462–602; reproduced in facsimile in Hellmann's Neudrucke, No. 8, Berlin 1897; and Hildebrandsson and Teisserenc de Bort's "*Les Bases de la Météorologie Dynamique,*" t. I, p. 228, 1907. See also W. Meinardus, *Die Entwickelung der Karten der Jahres-Isothermen von Alexandé von Humboldt bis auf Heinrich Wilhelm Dove,* Humboldt-Centenar-Schrift, Berlin, 1899.



HALLEY'S Chart of the Winds, *Philosophical Transactions* 1688. Classic throughout the 18th century.

well as first meteorological isogram chart) published was that of von Humboldt, 1817, who gave the name *isotherms* to the lines which he mapped; he employed records from 58 stations to give the distribution of annual mean temperatures over the globe. Kämtz improved upon this map in 1832, using 145 stations.[4] The next important landmark is the publication, in 1852, of Dove's "*Die Verbreitung der Wärme auf der Oberfläche der Erde,*" in which he, realizing the inadequacy of annual isotherms, first constructed isothermal charts of the globe for each month, employing records from 900 stations. The first chart of prevailing winds was that published by Halley in the *Philosophical Transactions,* 1688. This map remained classic throughout the eighteenth century; and not until well into the nineteenth century, when the need for the shortest possible sailing routes across the ocean arose, were further advances made.

Although theoretical isobars, in the form of straight lines parallel to the equator, had been drawn by H. K. W. Berghaus in 1839, the first isobaric chart based upon observational data was that of France and adjacent region published by Renou in 1864;[5] the first world chart was Buchan's, 1868.

The efforts of Maury finally succeeded in enlisting the cooperation of seafaring men, and led to the international congress at Brussels in 1853, at which a uniform plan for the utilization of marine observations, especially of winds, for the making of charts was agreed upon. The well-known "*Track and Pilot Charts*" resulted; while similar charts were published by France, Germany, and England. Meanwhile, the number of land meteorological stations was rapidly increasing in all regions of the world. World wide charts of isobars, isotherms, and prevailing winds were published by Alexander Buchan in 1871; Coffin's "*Winds of the Globe*" appeared in 1875; and the data had already been employed for theoretical investigations, *e. g.,* by Ferrel in his "*Meteorological Researches for the Use of the Coast Pilot,*" 1877 and earlier.

However, previous to the famous Challenger Expedition, 1872–1876, discussions of the fundamental problems of meteorology were forced to depend almost exclusively upon land observations; furthermore, all the then existing charts, mentioned above and which now possess only historical value, were based on necessarily defective and incomplete data. Hence, not only were arrangements made for frequent meteorological observations on the cruise, but also a subsequent rediscussion of all available information regarding the different atmospheric phenomena, with especial reference to the Challenger observations, was carried out by Buchan, and embodied in the great "*Report on Atmospheric Circulation*" forming pt. v. vol. II of the *Scientific Results,* 1889.

Buchan's annual and monthly charts of temperature, pressure, and prevailing winds, which are still in standard use, are based for the most part on land observations during the 15-year period 1870–1884, inclusive. In tropical and subtropical regions, where the mean pressure, etc., varies but little for the same month from year to year, it is not so important for purposes of comparative climatology and the construction of world maps that the observations be rigidly confined to the same period of time; but elsewhere, owing to the more or less marked instability which prevails with regard to the meteorological elements, *it is of the utmost importance to obtain series*

[4] Kämtz confirmed the existence of two "poles of cold," the existence of which had been suspected in 1820 by Brewster, who, from a study of Humboldt's chart, had come to the conclusion that the geographical poles were not the places of minimum temperature.

[5] Fuller historical information, with references to original literature, and facsimiles of maps, will be found in H. Hildebrandsson and L. Teisserenc de Bort, *Les Bases de la Météorologie Dynamique,* t. 1, 1907, pp. 185–228. See, in addition, C. F. Talman, List of Meteorological Isograms, Monthly Weather Review, 43, 195–198, 1915.

of observations covering, or capable of being reduced to, the same period of observation." Buchan used 1,366 stations for the pressure maps, 1,620 for temperature, and 746 for the winds, the whole embodying all the information existing, every source being drawn upon.

The first attempt at a systematic atlas of meteorology was the meteorological section of the *Berghaus Physical Atlas*, first published in 1887, and revised in 1895. In 1899 appeared vol. III, *Meteorology*, of *Bartholomew's Physical Atlas*. The charts presented in the latter are chiefly those of Buchan. No attempt has ever been made to utilize the accumulated observations since the publication of Buchan's charts in anything like so comprehensive a manner as was done by him. New, and slightly modified, maps for January, July, and the year have been drawn by Hann, and in their latest form are found in his *Lehrbuch der Meteorologie*, 2d and 3d editions. Detailed charts of various countries, based on the greater part of the vast mass of data now available, have been issued by the several meteorological services; but these are not usually strictly comparable with one another. Indeed, vast as the existing body of observational material is, it is in such form that in its entirety it is available to no one, and would not be manageable by any single person even if it were available to him; a digest of all existing climatological data is urgently needed, and the preparation of such a digest, if properly managed, would be a perfectly feasible task. Many of the best regional maps are reproduced in *Bartholomew's Atlas* (*l. c.*), and some issued later are readily obtainable from the meteorological services of the respective countries. In addition there may be mentioned: Rykatchev, *Atlas Climatologique de l'Empire de Russie*, St. Petersburg, 1900; Ekholm, *Sveriges temperaturforhallanden jamforda med det ofriga Europas*, Ymer, 1899; Teisserenc de Bort, *Annales du Bur. Cent. Met.*, 1881, vol. IV, pp. 1–13, Paris, 1883; and the publications of the recent polar expeditions, *e. g.*, Mohn, *Norwegian North Polar Expedition*, vol. VI, 1905 and Simpson, *British Antarctic Expedition, Meteorology*, vol. I, 1919; H. C. Dunwoody, *Summary of the International Meteorological Observations* (1878–1887, incl.), U. S. Weather Bureau Bull. A, 1893.

The best existing maps for France and adjacent regions are those of A. Angot in his *Études sur la climat de la France* (temperature, *Ann. Bur. Cent.*, 1903; pressure, *ibid.*, 1906; winds, *ibid.*, 1907), based on the data 1851–1900. The best available charts for Europe in general, and especially for Poland, are those in two notable publications, recently received from the latter country, by Gorczynski,[6] also for the period 1851–1900. New maps for the entire globe are also presented in these latter books, but the data used are not so reliable, particularly as regards homogeneity.

A very excellent series of small world charts is contained in the British Meteorological Office's *Barometer Manual for the Use of Seamen*, 9th ed., 1919; they are based on most of the data at present available.

The mapping of the ocean areas presents problems of its own. The isograms of the North Atlantic on Buchan's charts were based on the published international observations; those for the other oceans depended mainly upon coastal and island observations; the collection of marine meteorological data has gone steadily forward since the international congress of 1853, and has been continually utilized for the construction of marine meteorological charts published by the governments of the various maritime nations. In 1909 the U. S. Weather Bureau commenced the publication of a series of monthly charts of each ocean, based on practically all available data; after a few years their publication was continued, in a somewhat modified form, by the Hydrographic Office, and they have been reprinted, unchanged, each month since. This series constitutes probably the best of all such charts.

It seems to have fallen to the lot of the Dutch, however, to make the most comprehensive digest of the marine observations. In publication No. 104 of the Koninklijk Nederlandsch Meteorologisch Instituut appear monthly charts of the Indian Ocean utilizing the observations made from 1856–1912; and similar charts for the North Atlantic are now in process of publication.[7]

Special mention should also be made of the unique (and only) marine meteorological atlas, *Atlas de Météorologie Maritime, publié à l'occasion de l'Exposition Maritime Internationale*, Paris, 1887; which contains, besides the extensive text, Teisserenc's de Bort's pressure and wind charts of the globe, Brault's wind charts of the North Atlantic, surface water temperature maps, and numerous special charts.—*Edgar W. Woolard.*

[6] Władysław Gorczyński. O Ciśnieniu Powietrza w Polsce i w Europie, Warszawa, 1917; and Nowe Izotermy Polski, Europy i kuli Ziemskiej, Warszawa, 1918.

[7] See Kon. Ned. Met. Inst., No. 110, Oceanographische en Meteorologische Waarnemingen in den Atlantischen Oceaan, December, Januari, Februari, 1870–1914; 1,562,463 observations were utilized for this publication. (Reviewed, p. 412, below.)

NEW ISOTHERMAL CHARTS OF POLAND, EUROPE, AND THE GLOBE.

In a notable work by Wadysaw Gorczyński, recently received from Poland,[1] and which must have been largely prepared within sound of the guns during the World War, the distribution of temperature over Poland and over Europe is dealt with in great detail.

After a harmonic analysis of the diurnal variation of temperature at a number of stations in Poland, and at many localities widely scattered over the world, the question of the determination of true means is discussed. Annual and monthly means, and departures from the means, are formed for the period 1851–1900 at numerous stations in Poland and at 26 stations in Europe and Asia. The day-to-day variation of temperature is also discussed. This interdiurnal variation shows two maxima and two minima each year (in Poland these usually occur in January and May and in April and September, respectively); and its 10-year means for long records show a 30-year and 5-year period, the latter probably identical with Schuster's 4.8 year sun-spot period.

Probable errors and mean deviations are treated, and correlations made between the monthly means at one station and those at a number of other stations. Such correlations are greater and extend to greater distances in winter than in summer.

Detailed monthly and annual isothermal charts are then presented for Poland, for Europe, and for the entire globe, based on the data 1851–1900, with references to the literature used. Anomalies, extremes, amplitudes, etc., are charted and discussed. Finally, a detailed treatment of all the different systems of classification of climates which have been proposed is given, and applied to the climatology of Europe and the world. The volume closes with a sketch of the geography and climatology of Poland, having for its object the justification of the claim that Poland is entitled to recognition as a separate and distinct independent country.—*E. W. W.*

[1] W. Gorczyński, Nowe Izotermy Polsi, Europy, i kuli Ziemskie (Nouvelles Isothermes de la Pologne, de l'Europe, et du Globe terrestre), Warsaw, 1918.